Testing Low Viscosity Fluids with the HAAKE Viscotester iQ Air

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Key words
Rheology, Low Viscosity, Water-like

Introduction

Testing water on a rotational rheometer always poses a challenge due to the low torque reading arriving at the transducer. This is especially true for the smallest commercially available air-bearing rheometer on the market, the new Thermo Scientific™ HAAKE™ Viscotester™ iQ Air. Equipped with a low friction double-sperical air bearing, the lower torque limit of the HAAKE Viscotester iQ Air is 10 µNm and thus about 3 orders of magnitude higher compared to a research grade rheometer like the Thermo Scientific™ HAAKE™ MARS™ 60. Still, many relevant rheological QC tests conducted in industries like i.e. food, petroleum or coatings deal with ultra low viscosity fluids. In this application note it is shown how extremely low viscous fluids like i.e. water can be tested with the new HAAKE Viscotester iQ Air.

Experimental Results and Discussion

The setup used to perform the tests on water is shown in Fig. 1. The HAAKE Viscotester iQ Air was equipped with the new 48 mm diameter liquid temperature controlled cylinder TM-LI-C48 and the corresponding double gap rotor CCB41 DG.
To obtain meaningful data on such a low viscous fluid the measuring routine has to be adjusted accordingly. Fig. 2 shows the Thermo Scientific™ HAAKE™ RheoWin™

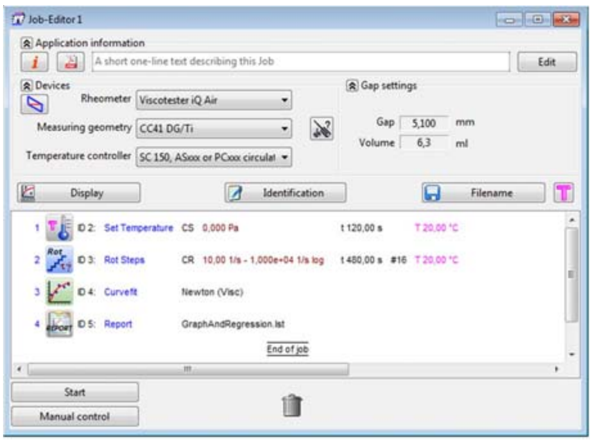

Fig. 2: Thermo Scientific HAAKE RheoWin routine to test low viscosity fluids on the HAAKE Viscotester iQ Air.

Fig. 1: Thermo Scientific HAAKE Viscotester iQ Air with TM-LI-C48.

routine used for the tests shown below. One of the most important parameters for such a test is the period of time for every single measuring point as well as the integration time. Here, a measuring time of 45 s was used in combination with an integration time of 15 s. Temperature Control was achieved via an external circulator SC100-A10 from Thermo Scientific. Measuring temperature was 20 °C (68 °F) and an equilibration time of 3 minutes was chosen.
In addition to the rheological test, the automated data evaluation and report functionalities of the HAAKE RheoWin software have been used.

Fig. 3 shows the results of 5 separate test runs of this method on water.

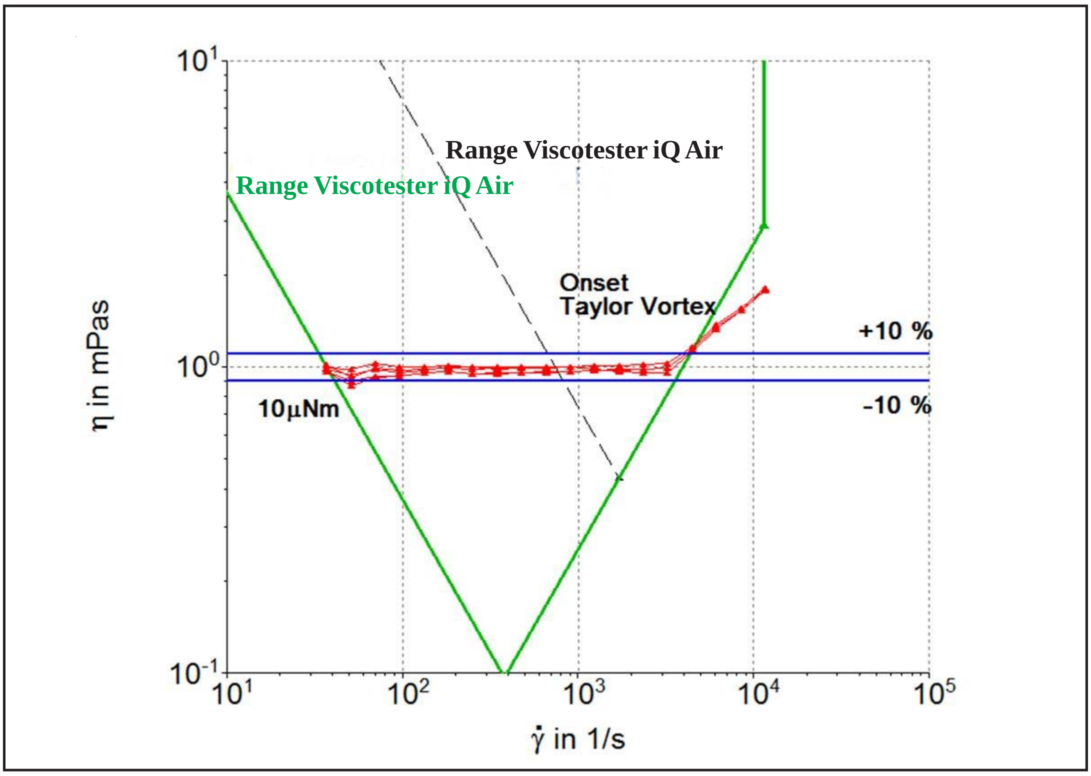

Fig. 3: Viscosity as a function of shear rate for water at 20 °C on the HAAKE Viscotester iQ Air. The data is plotted on a logarithmic scale.

As can be seen in Fig.3 the results are extremely reproducible starting from a torque of 10 µNm. Also all measured values are within a 10% tolerance as indicated by the blue lines. Comparing the accessible shear rate range to that of a standard HAAKE Viscotester iQ, one can see that the air-beared model adds more than one order of magnitude into the low-shear regime. Off course the accessible shear rate range is still limited, however water can be tested with the Viscotester iQ Air over roughly 2 orders of magnitude from approx. 30 to 3000 s^{-1}. Below 30 s^{-1} the torque reading is below specification, above 3000 s^{-1} an increase of viscosity can be monitored due to the onset of Taylor vortices [1]. This onset arises exactly where it was predicted by the RheoWin *Range Calculator* as can be seen in Figure 4.

To further emphasize the quality and reproducibility of the data, Fig. 5 shows the same results like in Fig. 3 again, however this time plotted on a linear scale.
As can be seen in Fig. 5 the Viscotester iQ Air is easily able to measure water with a large diameter double gap rotor. Before onset of the Taylor instabilities, all data is within ± 10% of the theoretical water viscosity of 1.00 mPas (cP) at 20 °C.

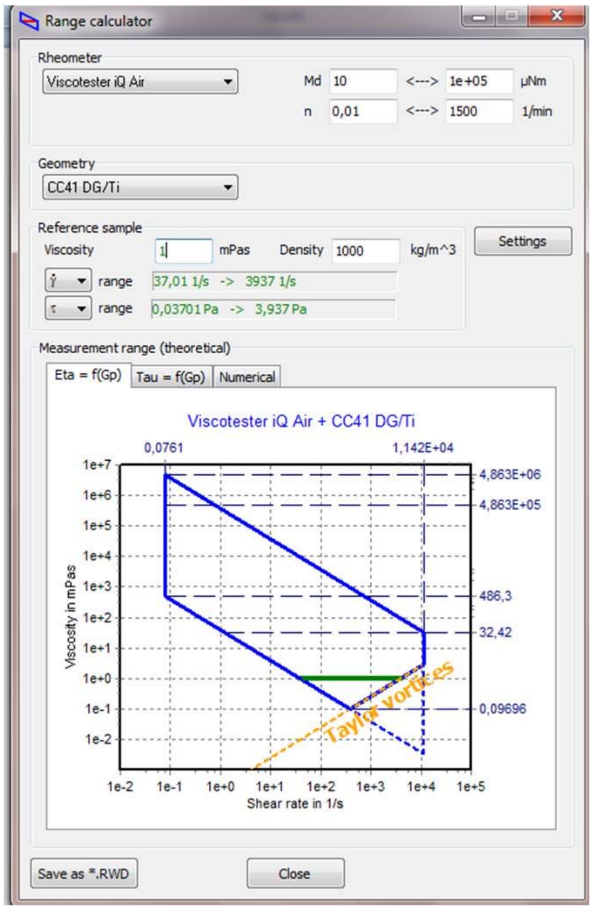

Fig. 4: Calculated Measuring Range for the HAAKE Viscotester iQ Air with rotor CCB41 DG with Taylor vortex prediction taken directly from the HAAKE RheoWin Software.

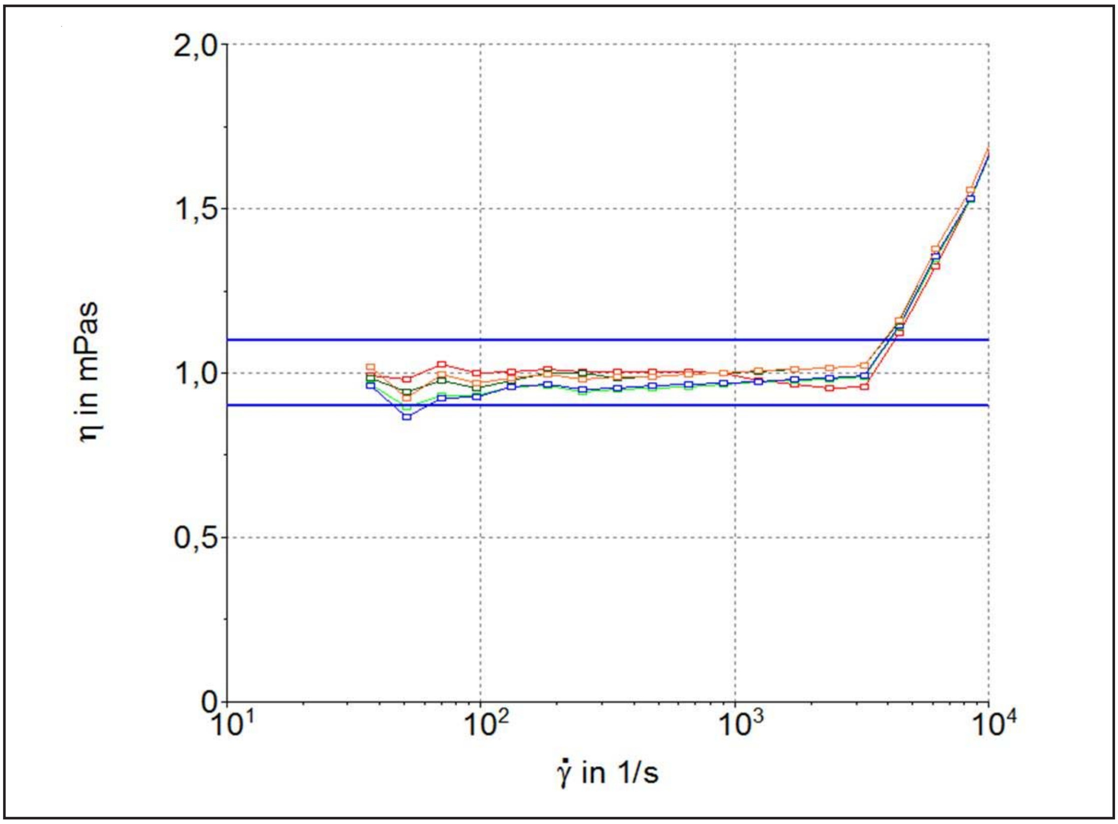

Fig. 5: Viscosity as a function of shear rate for water at 20°C on the HAAKE Viscotester iQ Air. The data is plotted on a linear scale.

Conclusions

The Thermo Scientific HAAKE Viscotester iQ Air is a quick, simple and accurate rheometer for Quality Control. The smallest commercially available air-bearing rheometer in the market can easily and correctly determine the viscosity of extremely low viscous fluids like water over a wide range of shear rates.

Literature

[1] Taylor, G.I. "Stability of a Viscous Liquid contained between Two Rotating Cylinders“. Phil. Trans. Royal Society A223 (605–615): 289–343, **1923**.

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